

Climate Change Scenarios for the Columbia River Basin: A Comparison of CMIP3 and CMIP5



July 2013

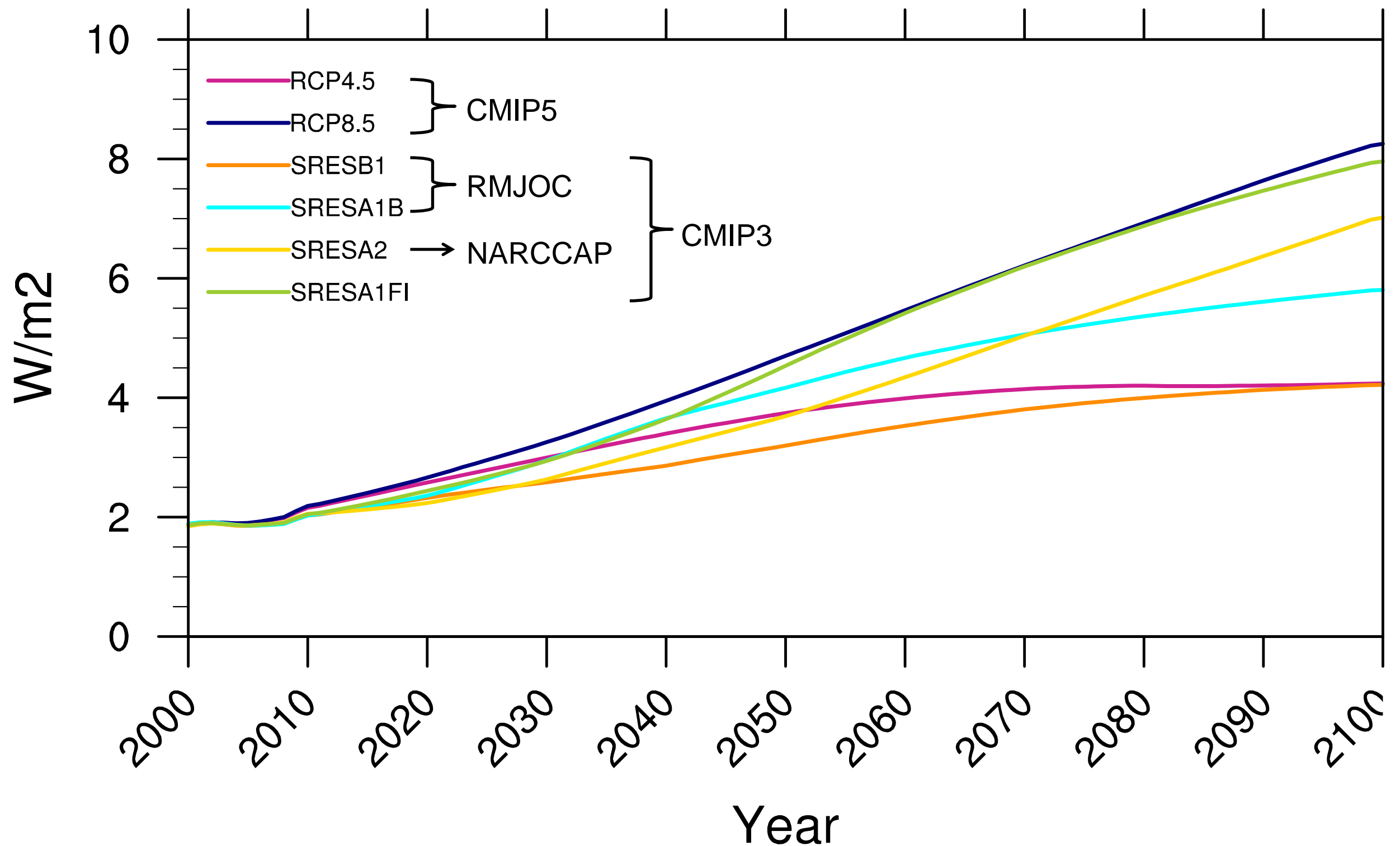
Meghan Dalton, David Rupp, Darrin Sharp, and Philip Mote

Report Outline

- A. Overview of the Coupled Model Intercomparison Project phase 3 (CMIP3) and phase 5 (CMIP5).
- B. Evaluation/ranking of CMIP5 global climate models (GCMs) for the Pacific Northwest.
- C. Columbia River Basin climate scenarios from CMIP3, CMIP5, and NARCCAP.

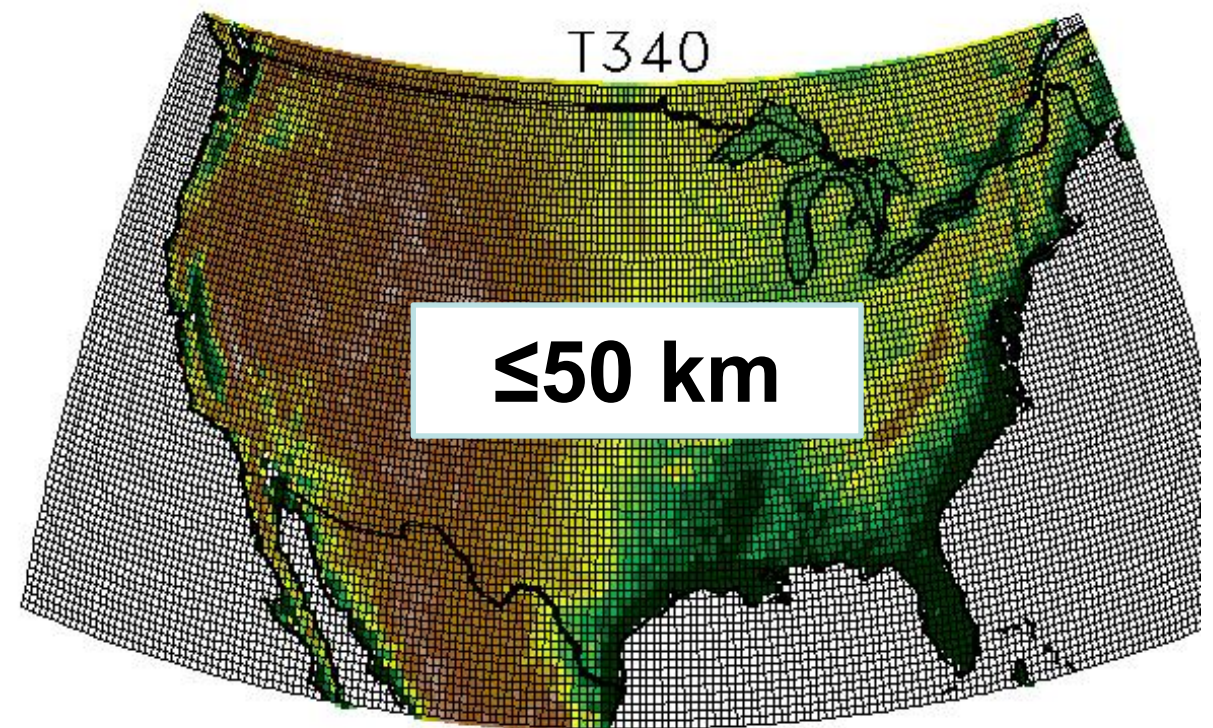
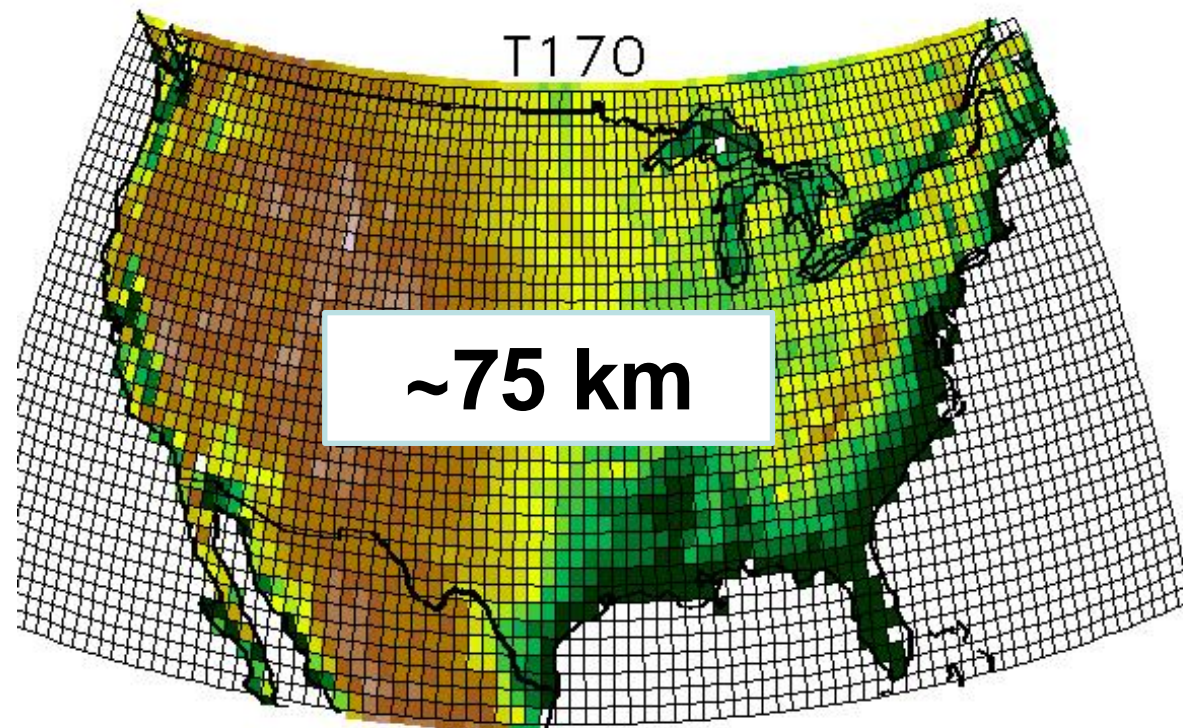
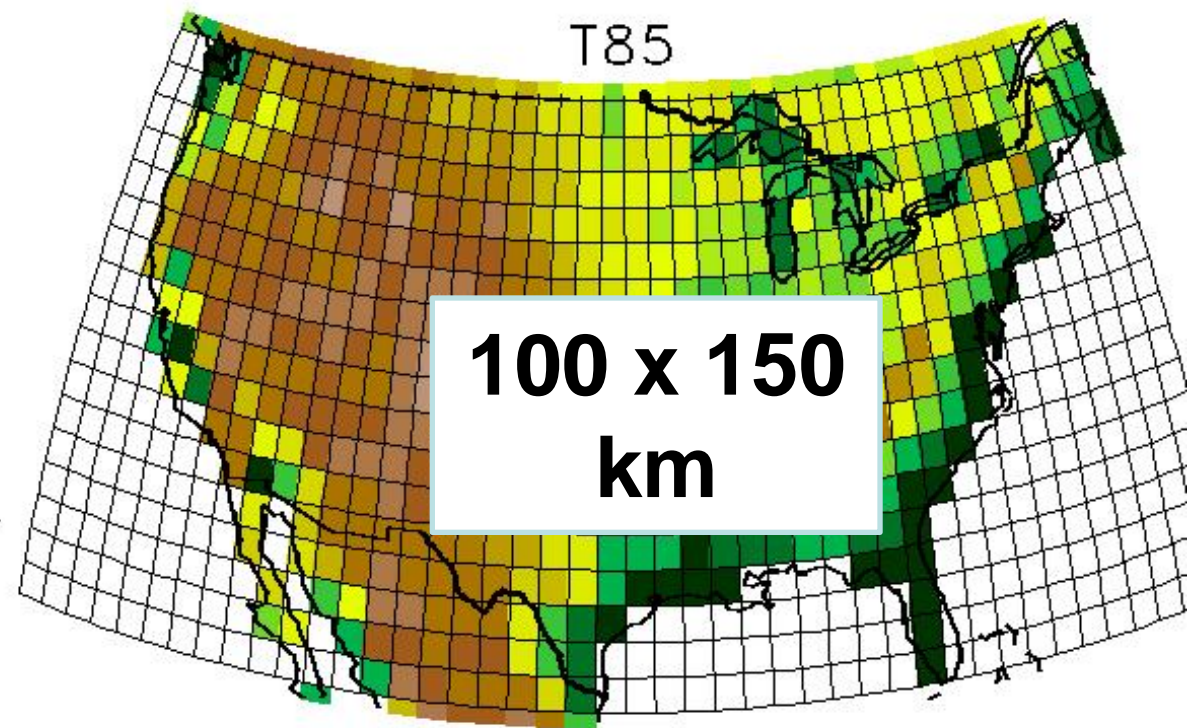
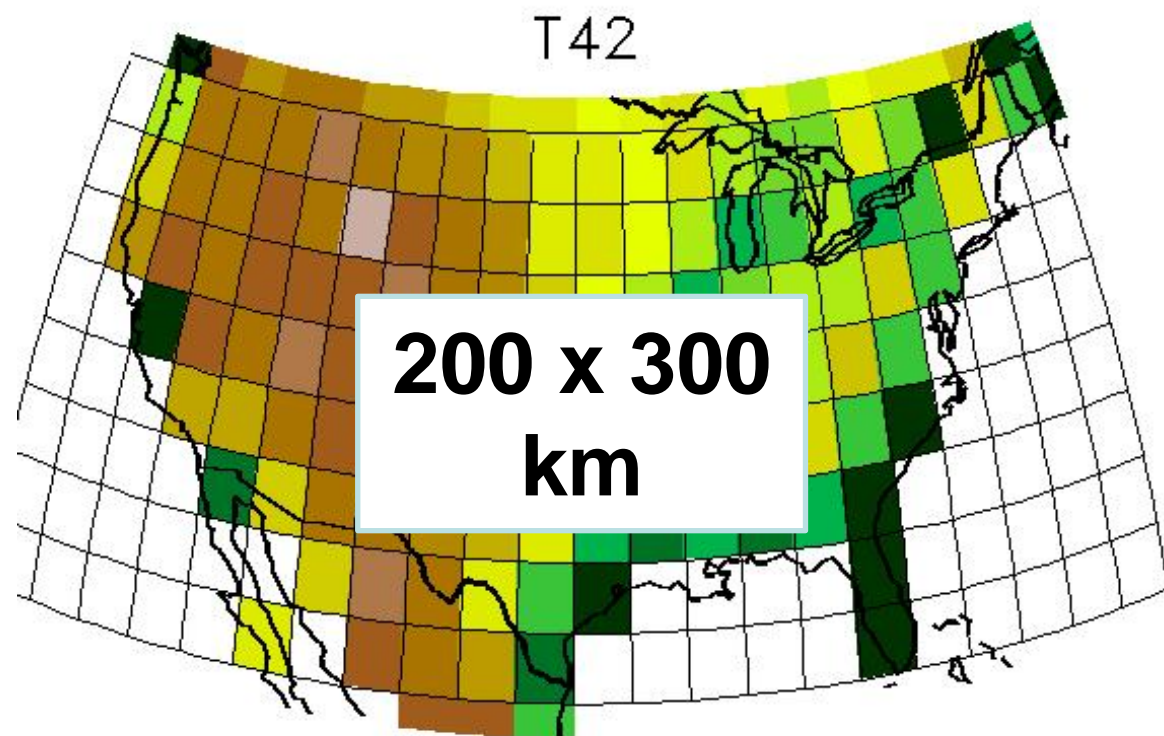
Overview of the Coupled Model Intercomparison Project phase 3 (CMIP3) and phase 5 (CMIP5)

Total Radiative Forcing



Data source: *live.magicc.org*

Resolution



Large Scale Simulation Improvements

Climate Sensitivity

- CMIP3: 2.1-4.4 °C/doubling CO₂
- CMIP5: 2.1-4.7 °C (3.8-8.5 °F)/doubling CO₂

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- CMIP5: slight improvements in mid- to high-latitudes
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El Niño-Southern Oscillation

- CMIP5: improved onset and peak location of ENSO events; reduced cold bias in western eq. Pacific; no marked improvement in associated atmospheric processes that drive ENSO characteristics
- CMIP3 & CMIP5: difficulty simulating 2-7 year frequency
- CMIP3 & CMIP5: little to no change in 21st century ENSO amplitude relative to natural variability

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Climate

- Similar skill between CMIP3 and CMIP5

Evaluation & ranking of CMIP5 global climate models (GCMs) for the Pacific Northwest US

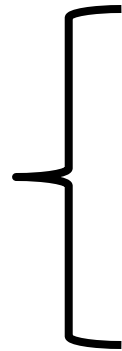
20th century climate

Performance Metrics

Metric	Description
Mean-T Mean-P	Mean annual temperature (T) and precipitation (P), 1950-1999.
SeasonAmp-T SeasonAmp-P	Mean amplitude of seasonal cycle as the difference between warmest and coldest month (T), or wettest and driest month (P). Monthly precipitation calculated as percentage of mean annual total, 1950- 1999.
DTR-MMM	Mean diurnal temperature range, 1950-1999.
SpaceCor-MMM-T SpaceCor-MMM-P	Correlation of simulated with observed the mean spatial pattern, 1950-1999.
SpaceSD-MMM-T SpaceSD-MMM-P	Standard deviation of the mean spatial pattern, 1950-1999. All standard deviations are normalized by the standard deviation of the observed pattern.
TimeVar.1-T TimeVar.8-T	Variance of temperature calculated at frequencies (time periods of aggregation) of 1 and 8 years, 1901-1999.
TimeCV.1-P TimeCV.8-P	Coefficient of variation (CV) of precipitation calculated at frequencies (time periods of aggregation) of 1and 8 water years, 1902-1999.
Trend-T Trend-P	Linear trend of annual temperature and precipitation, 1901-1999.
ENSO-T ENSO-P	Correlation of winter temperature and precipitation with Niño3.4 index, 1901-1999.
Hurst-T Hurst-P	Hurst exponent using monthly difference anomalies (T) or fractional anomalies (P), 1901-1999.

Performance Metrics

Eastern N. Pacific/
Western N. America



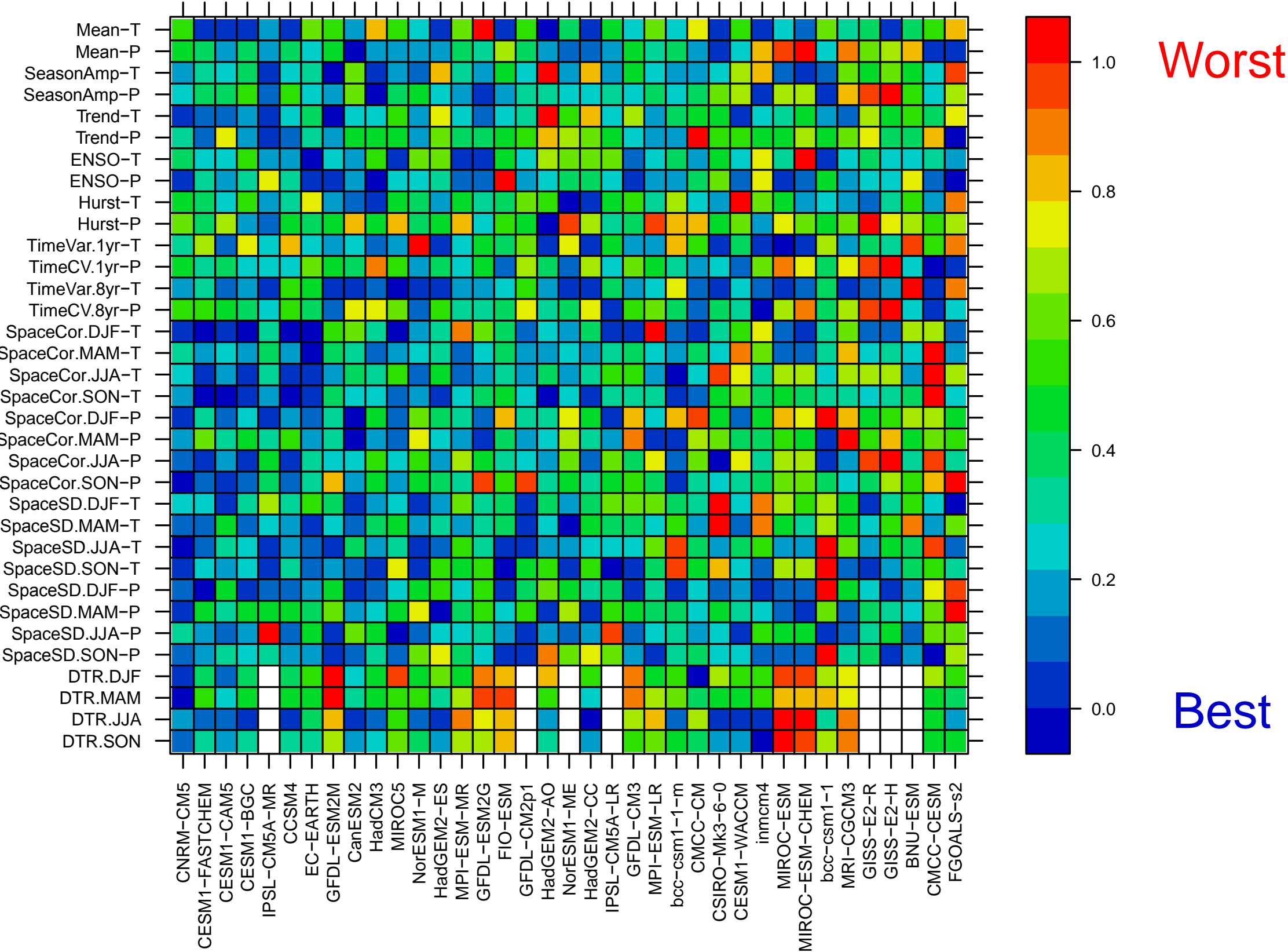
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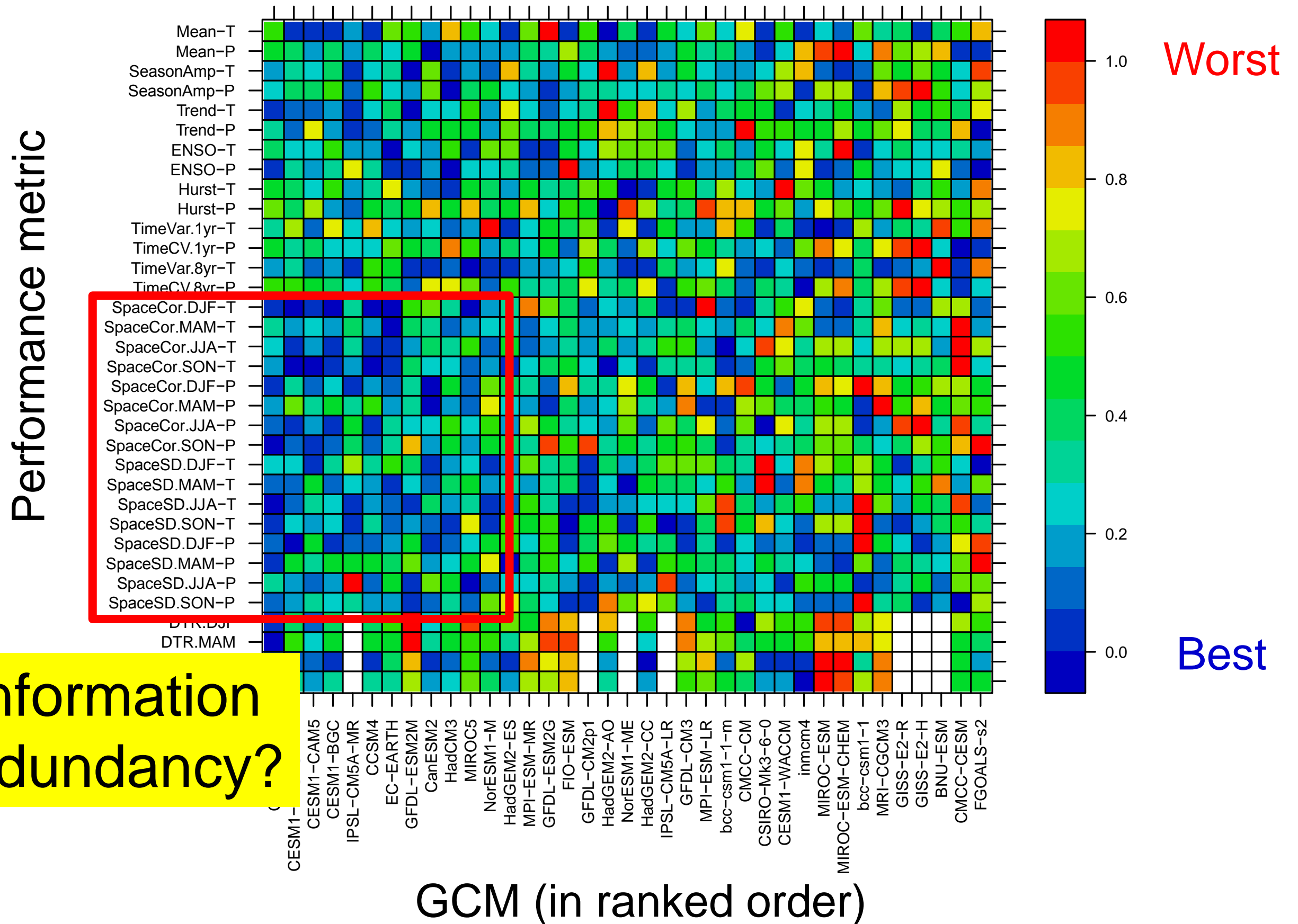
Relative GCM error for 34 performance metrics

Performance metric

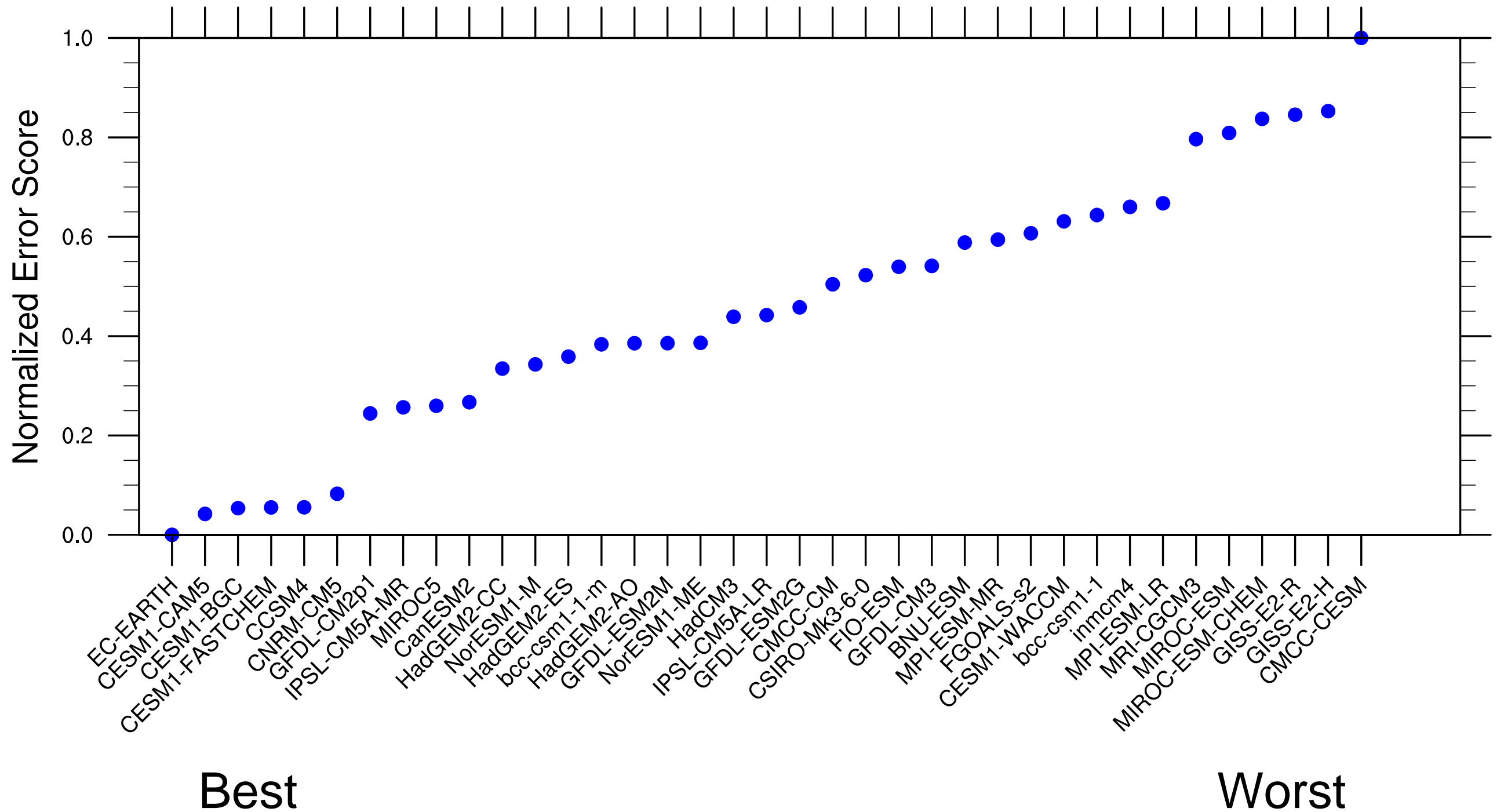


GCM (in ranked order)

Relative GCM error for 34 performance metrics



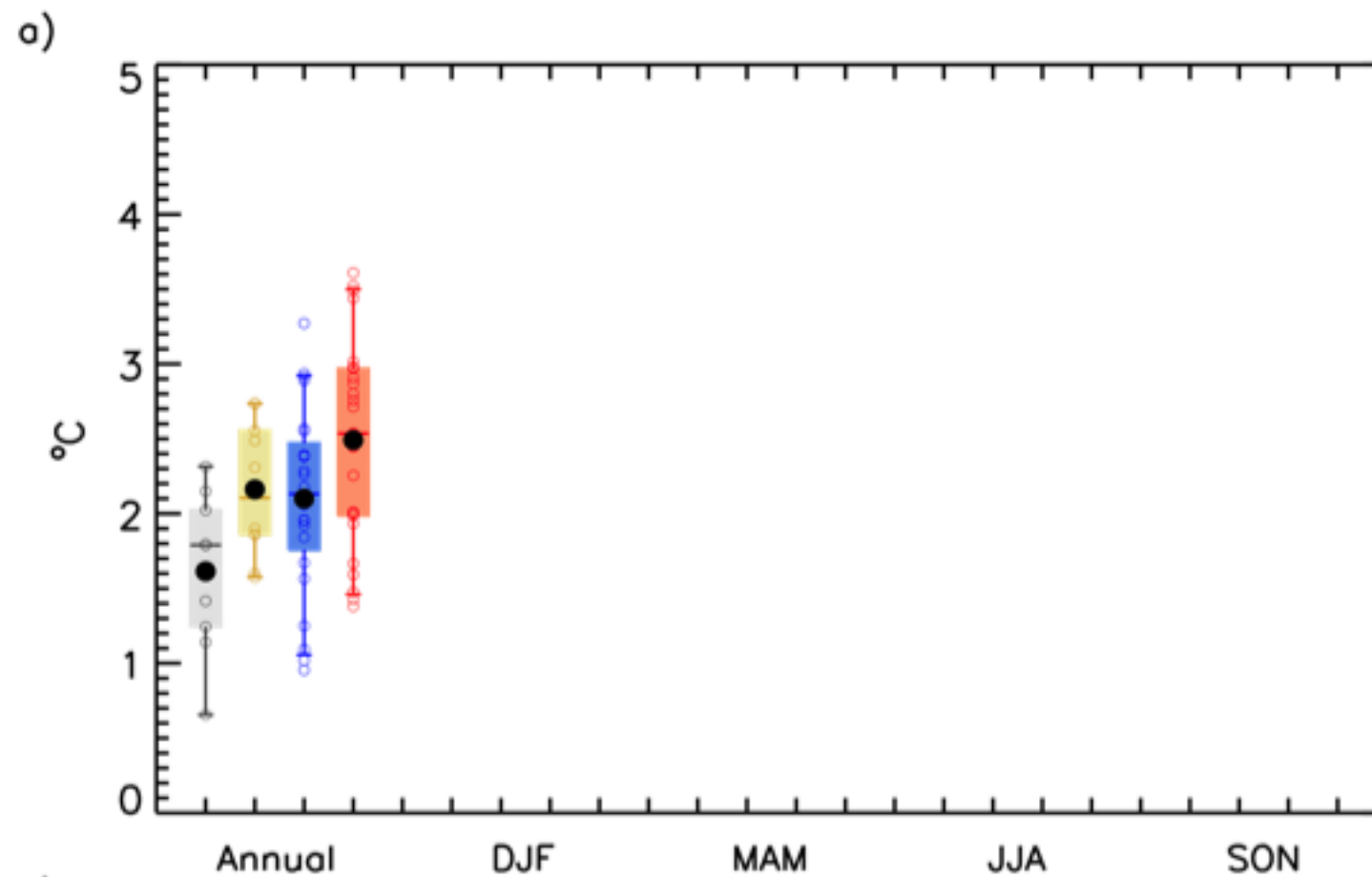
Ranking with empirical orthogonal function (EOF) analysis on 16 performance metrics



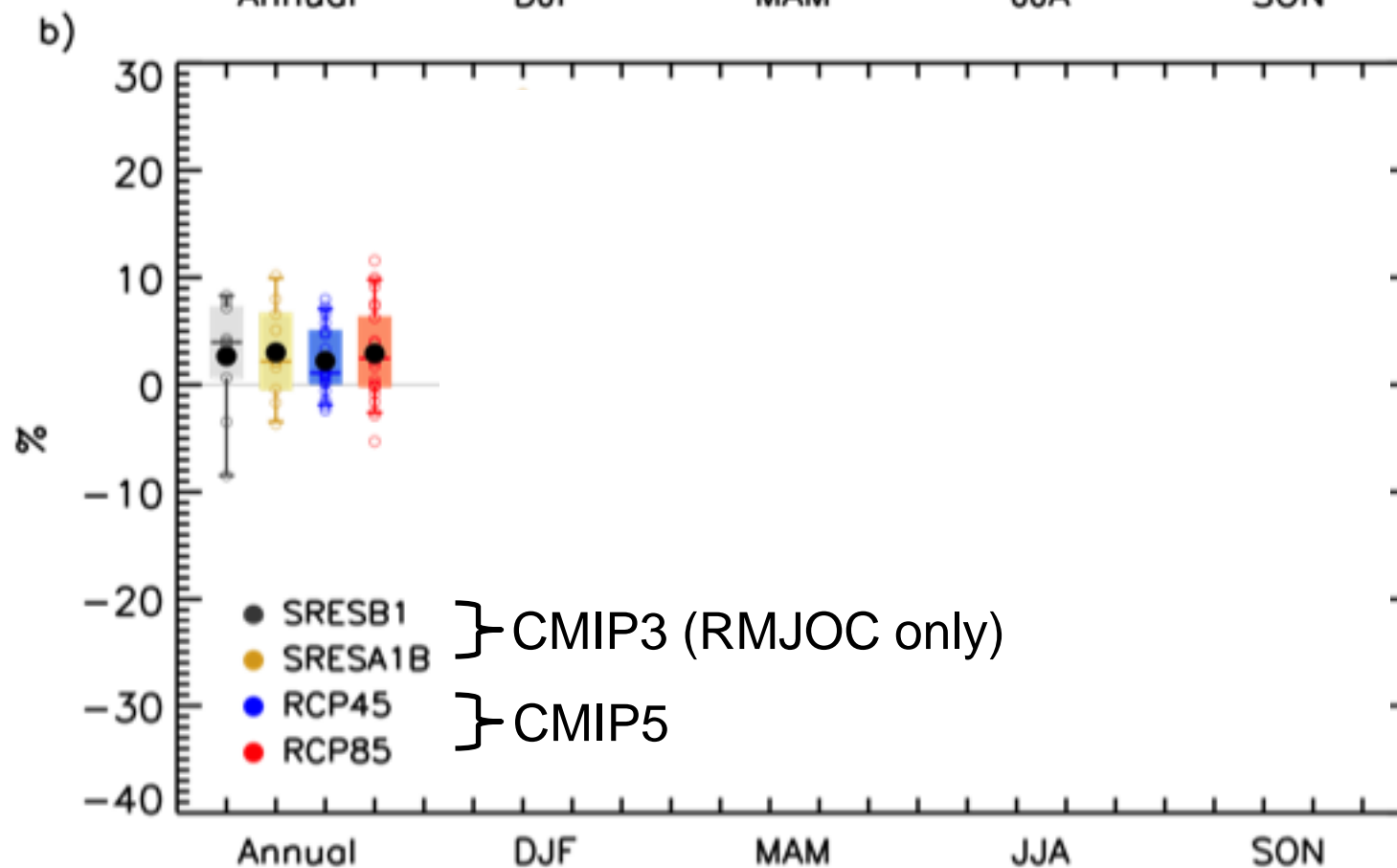
Columbia River Basin Climate Scenarios from CMIP3, CMIP5, and NARCCAP

2040s* Climate Projections for the Columbia River Basin

Temperature



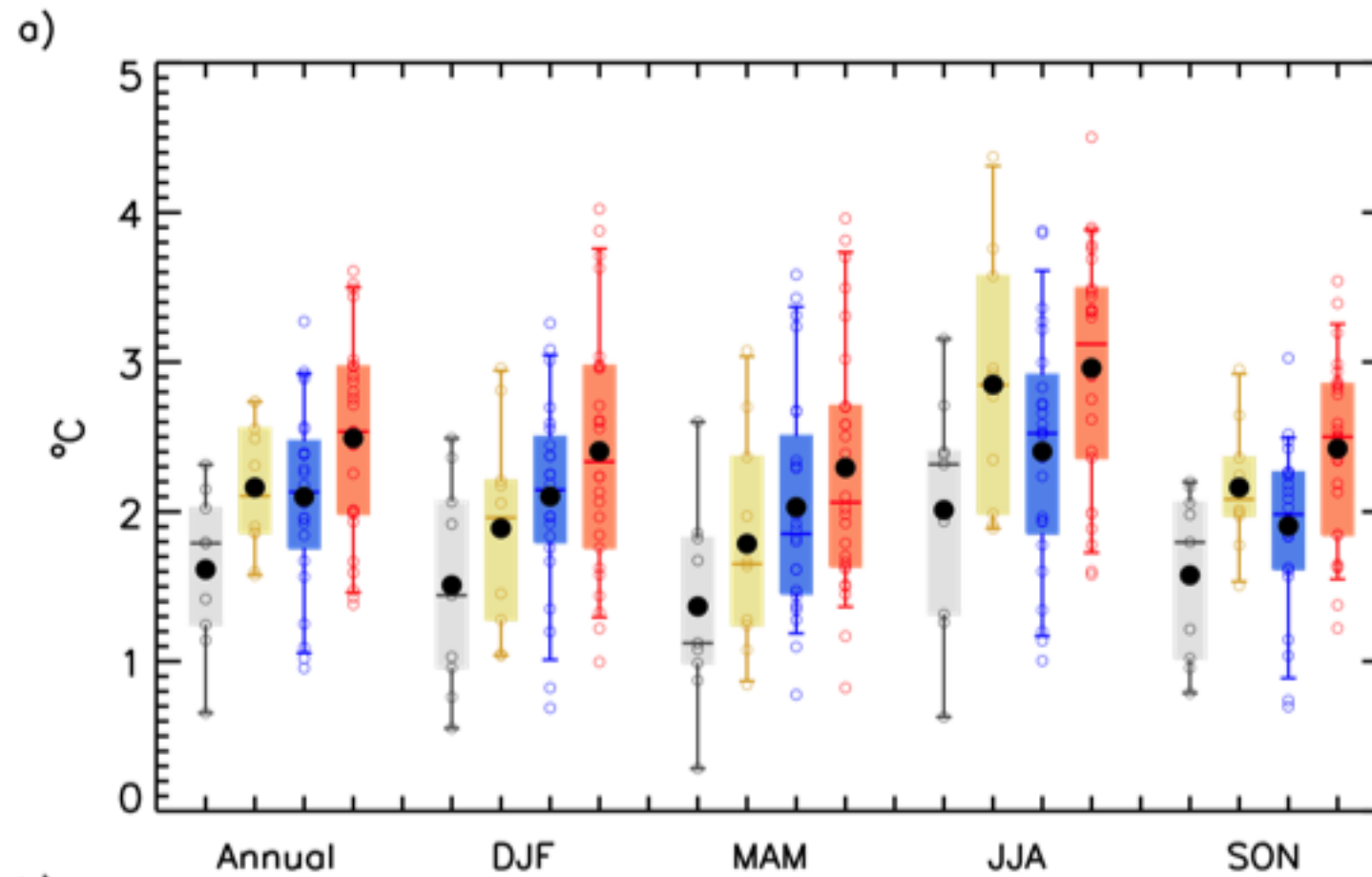
Precipitation



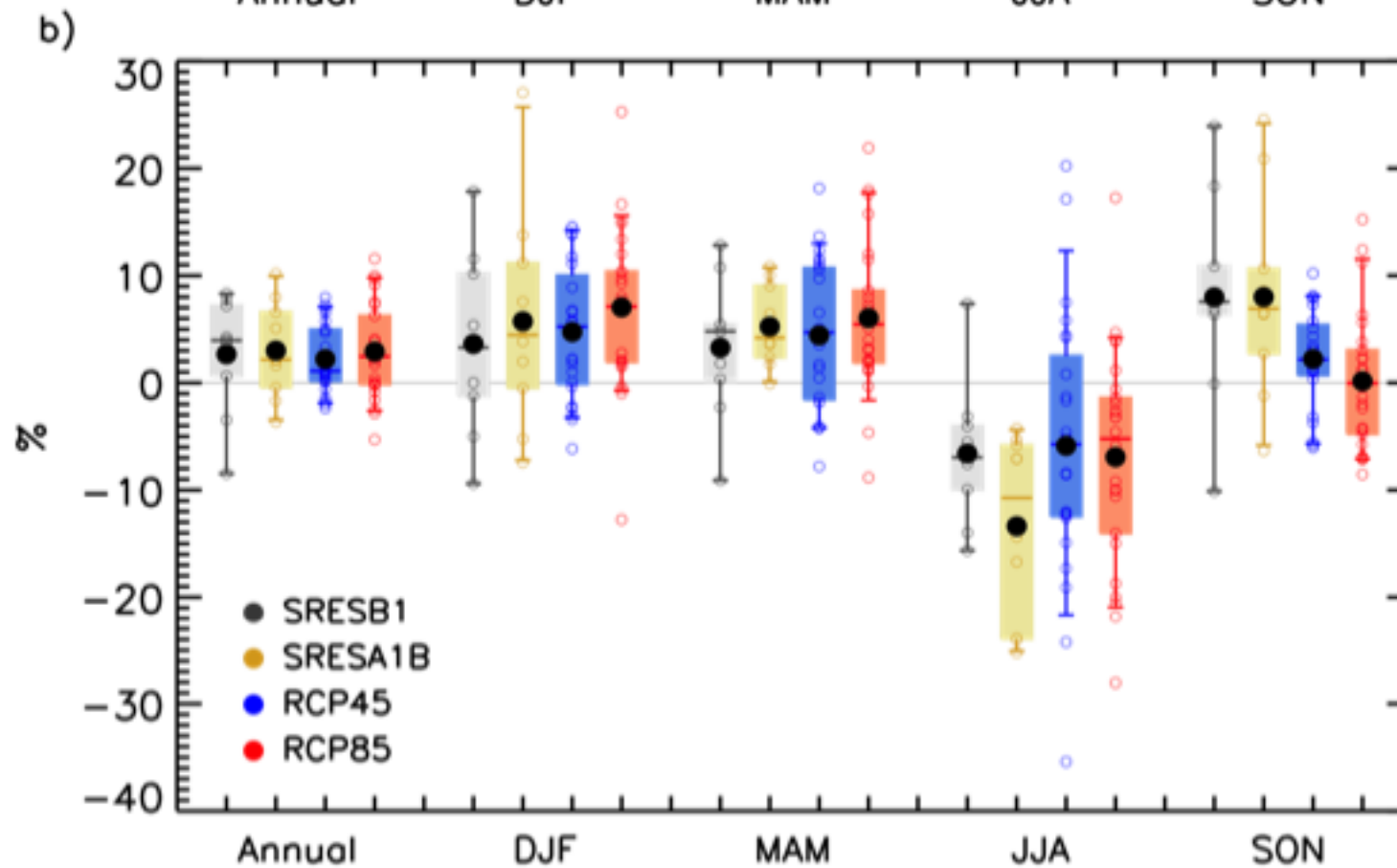
*1970-1999 to 2030-2059

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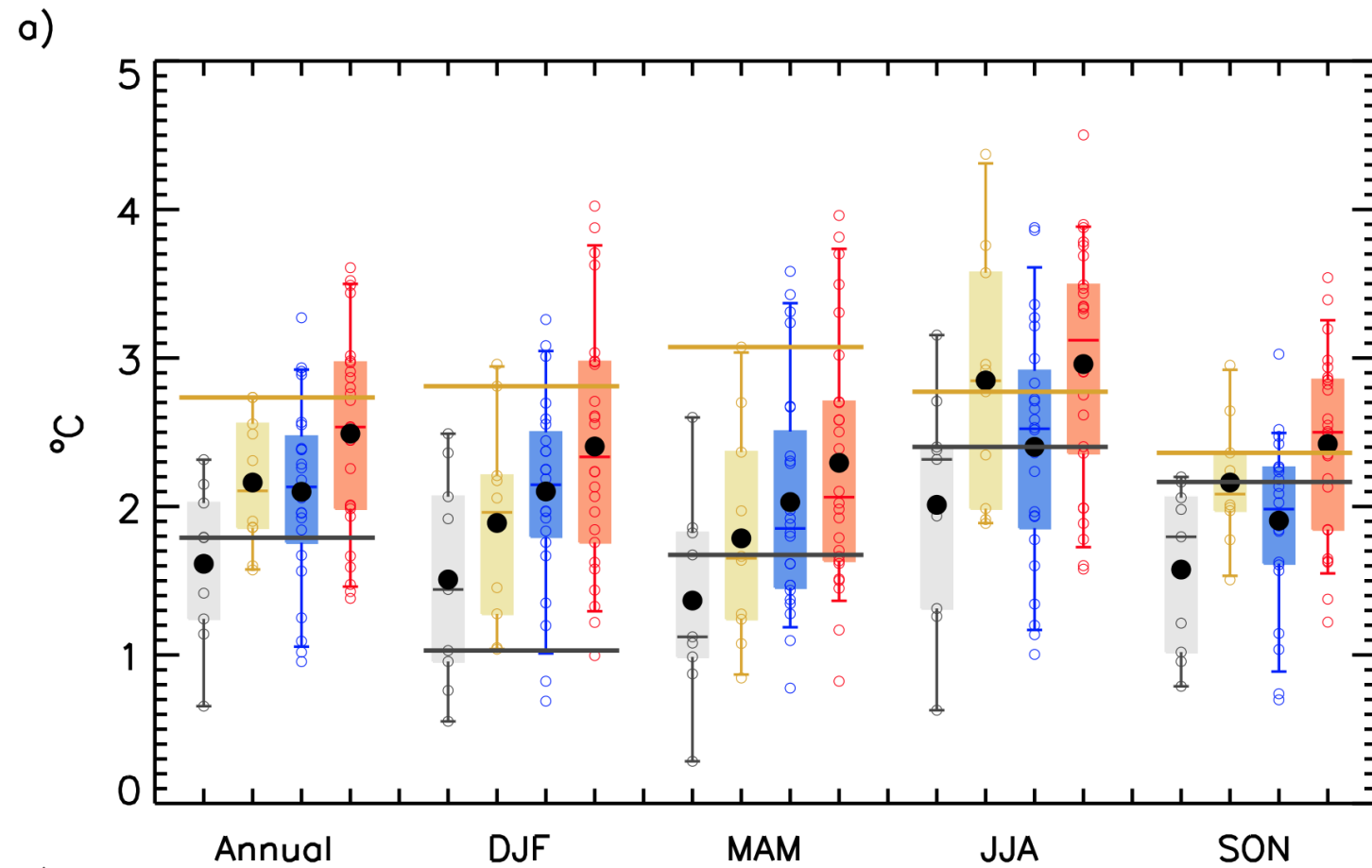
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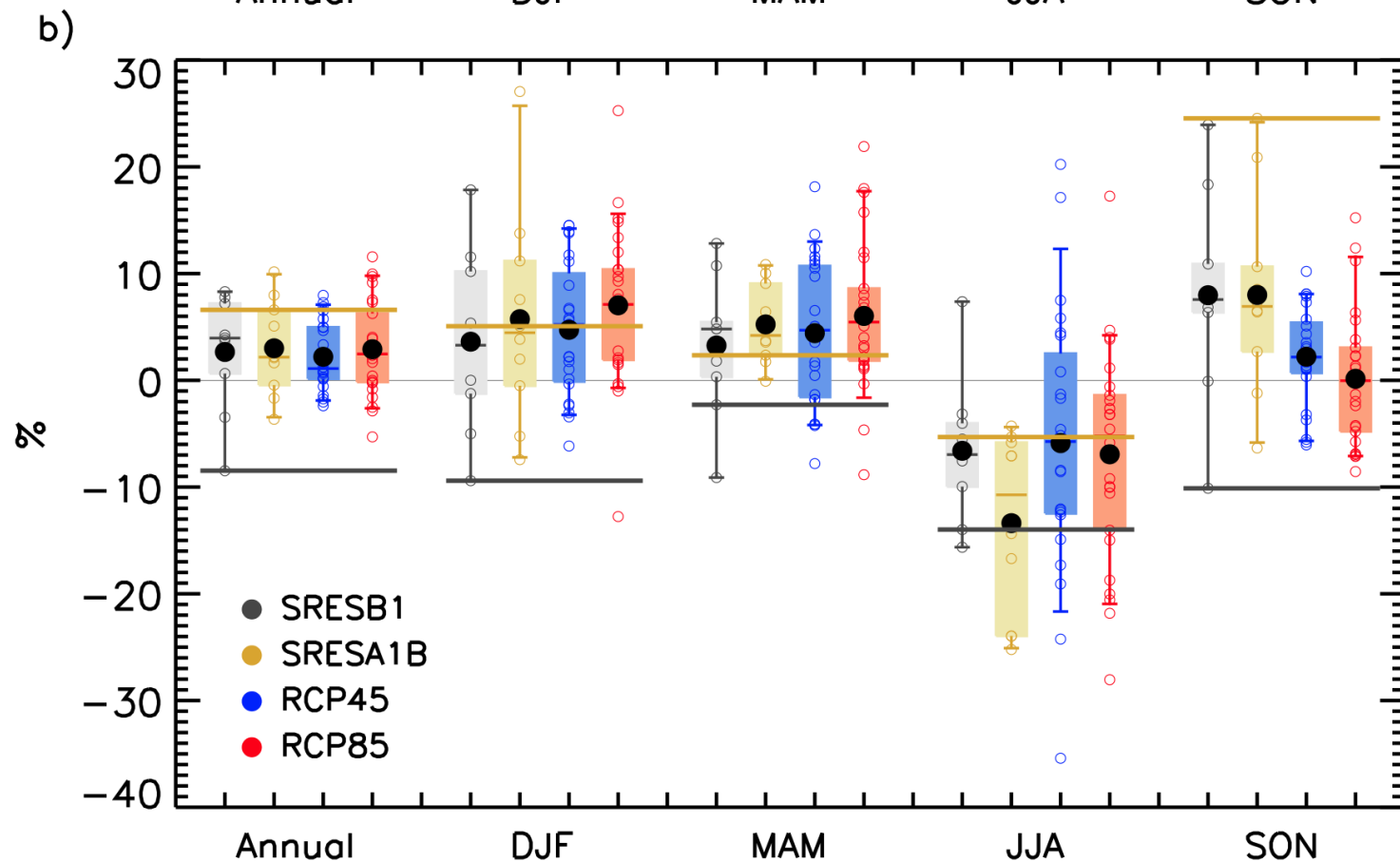
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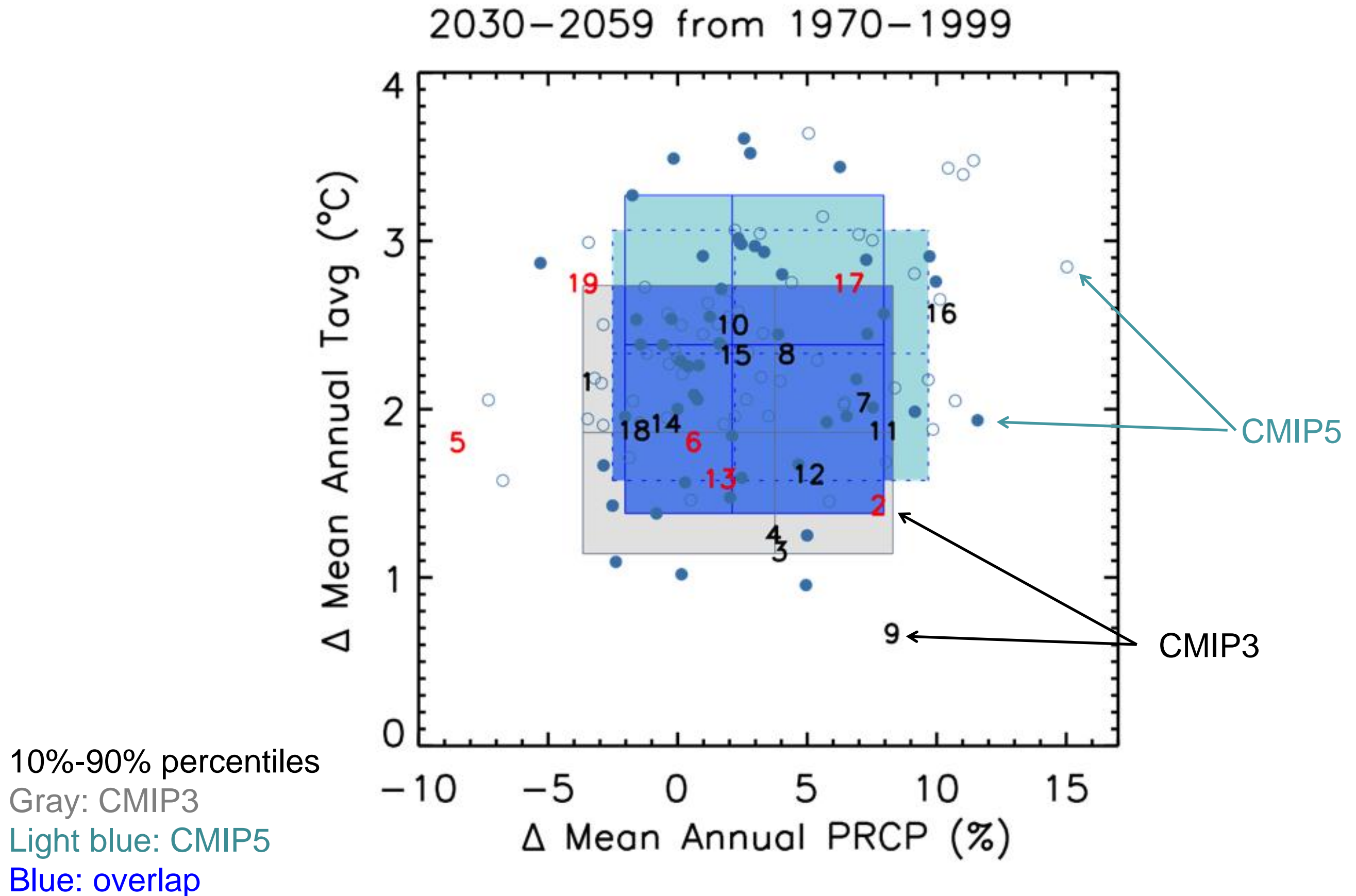


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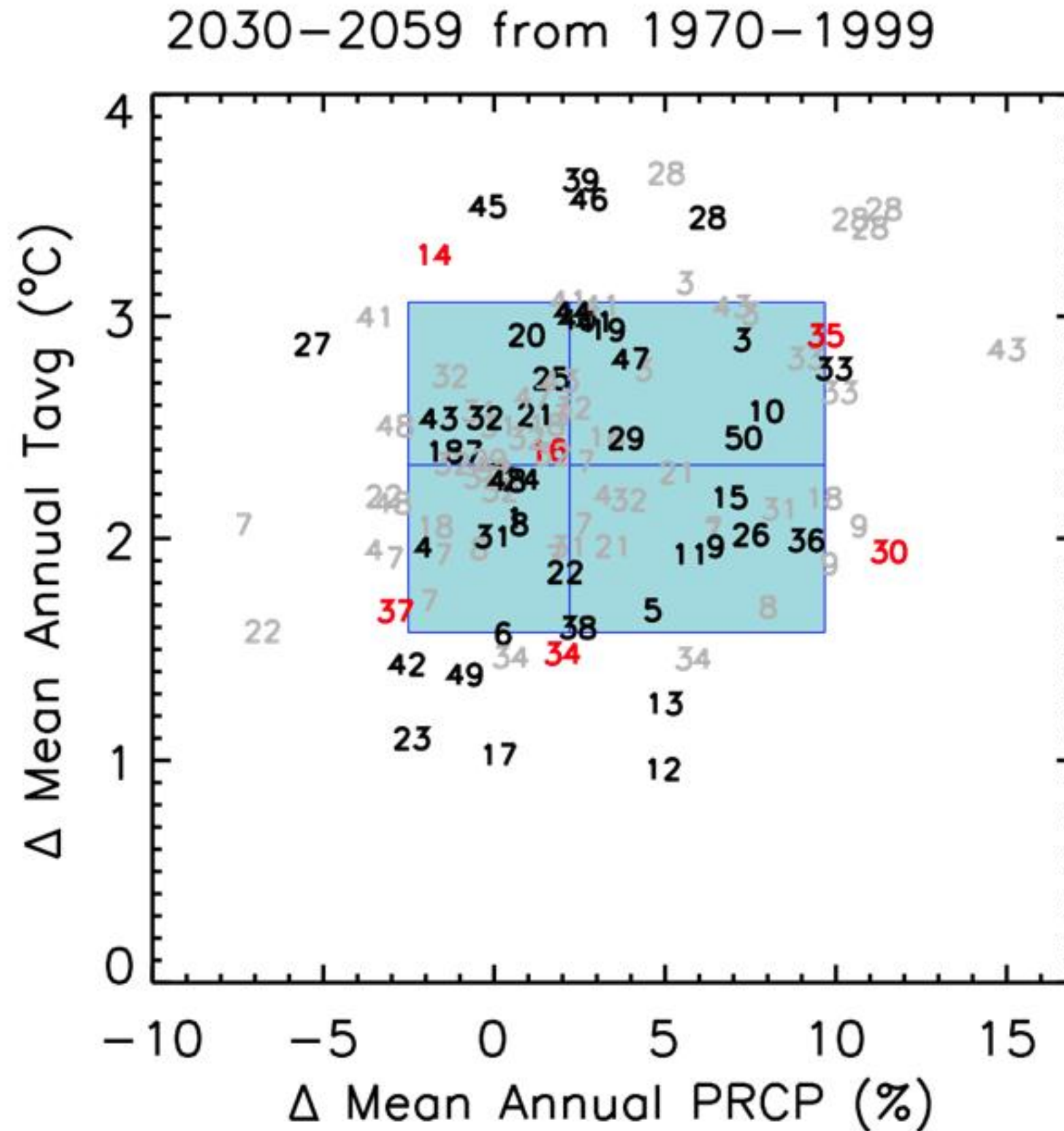
17

5

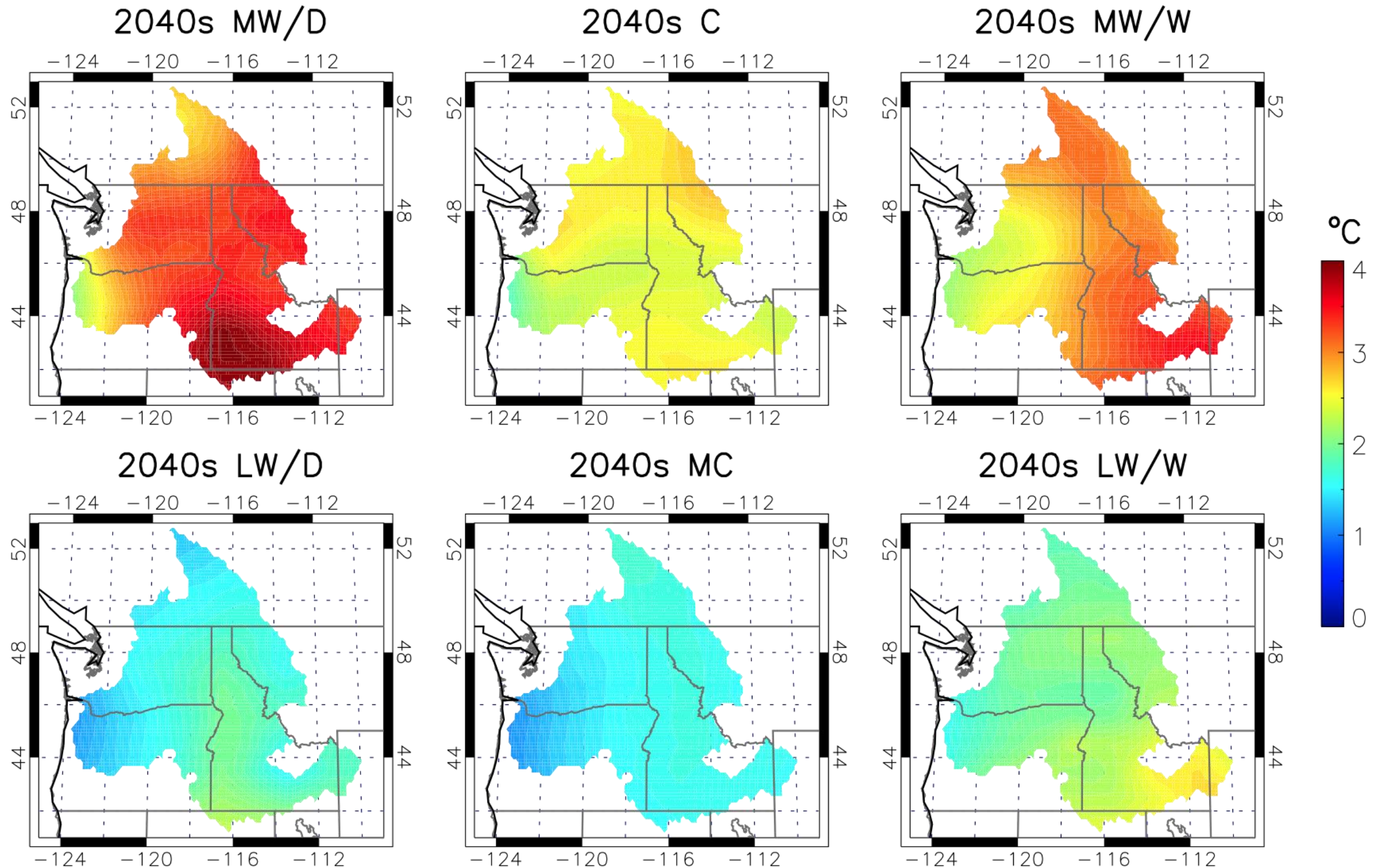
Climate Projections for the Columbia River Basin



CMIP5 Climate Projections for the Columbia River Basin



BCSD-CMIP5 2040s Temperature Change Projections



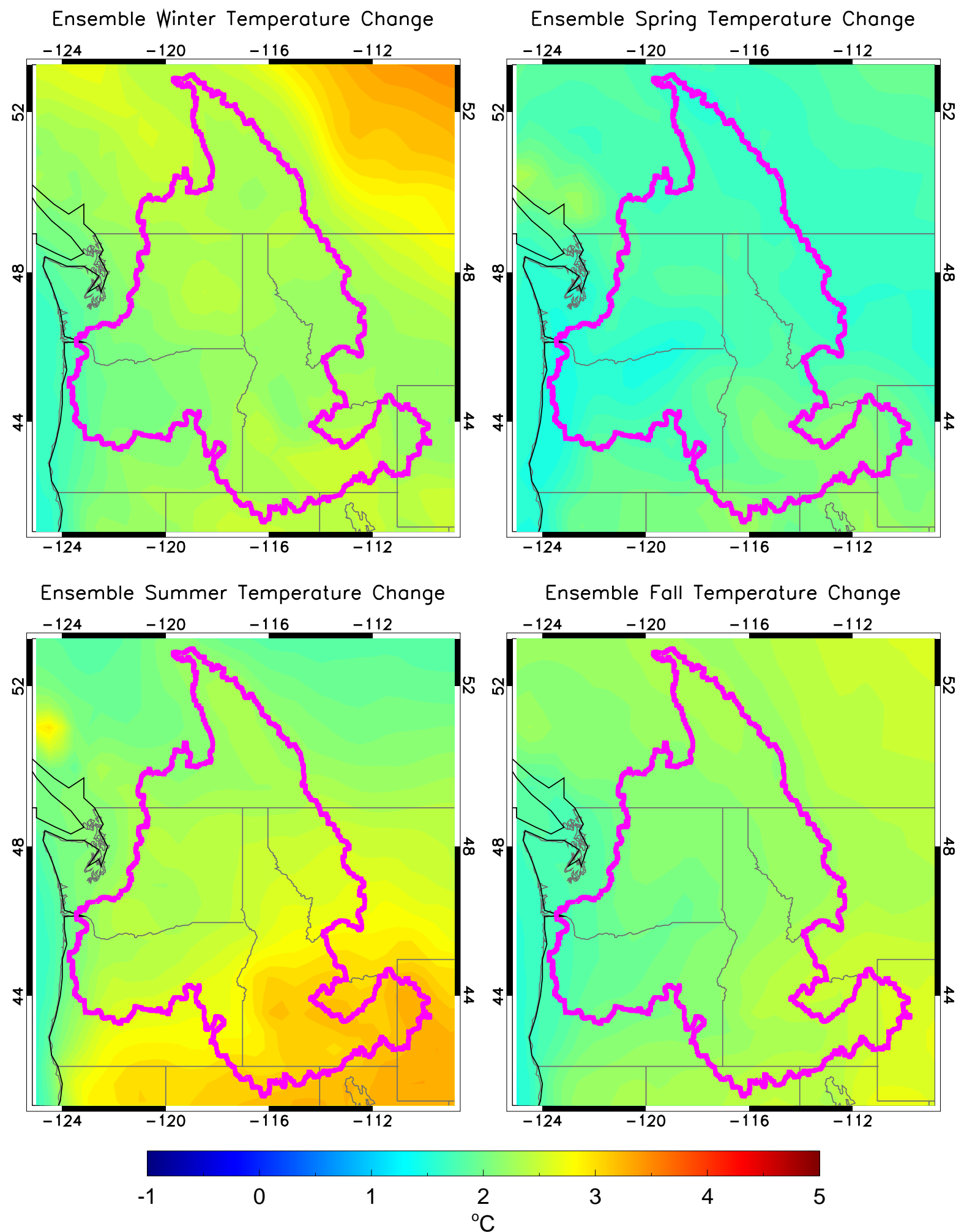
MW/D = moderate warming and dry
LW/D = low warming and dry

C = central change
MC = minor change

MW/W = moderate warming and wet
LW/W = low warming and wet

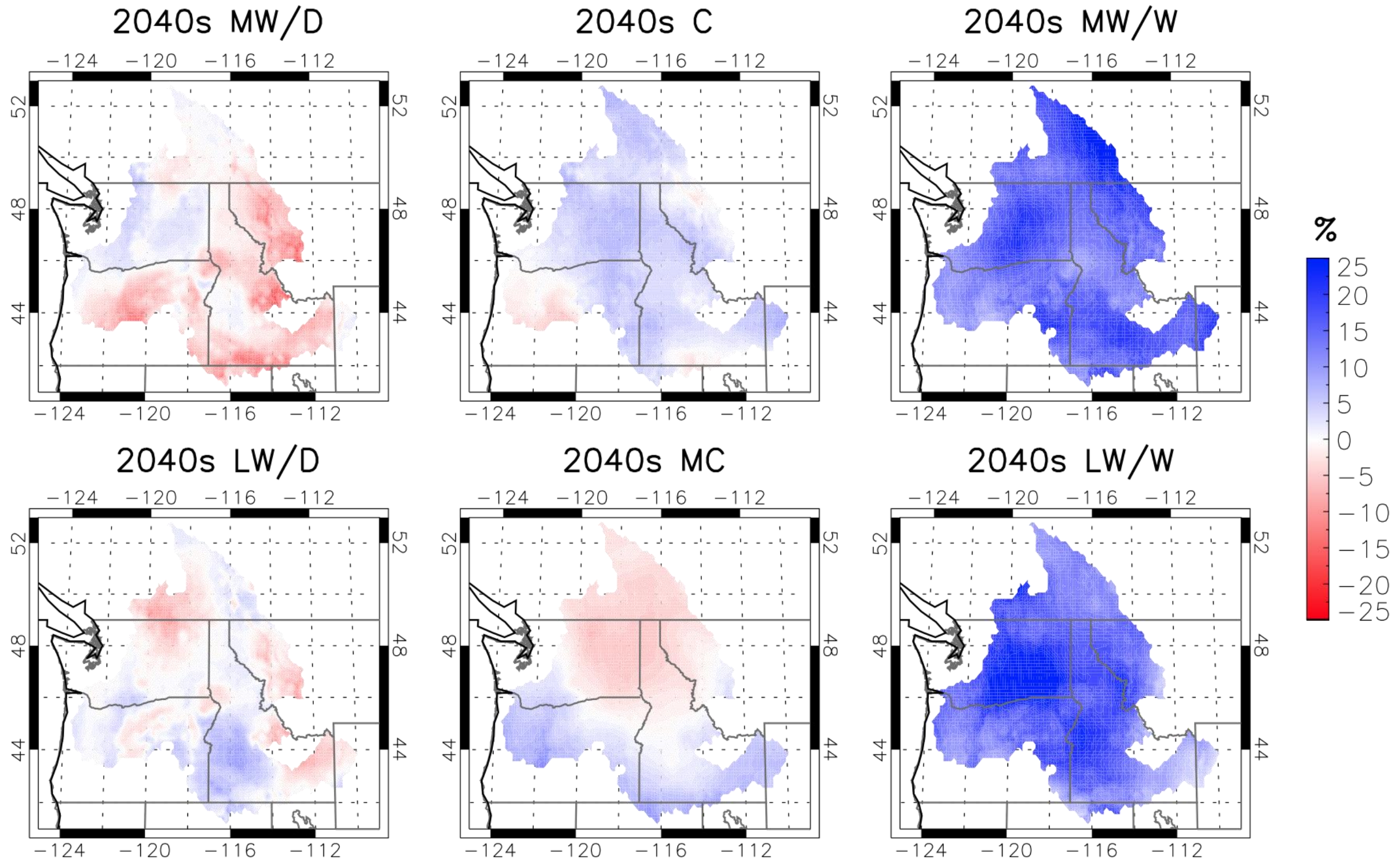
NARCCAP 2050s* temperature change

Average of 9
simulations



*1970-1999 to 2040-2069

BCSD-CMIP5 2040s Precipitation Change Projections



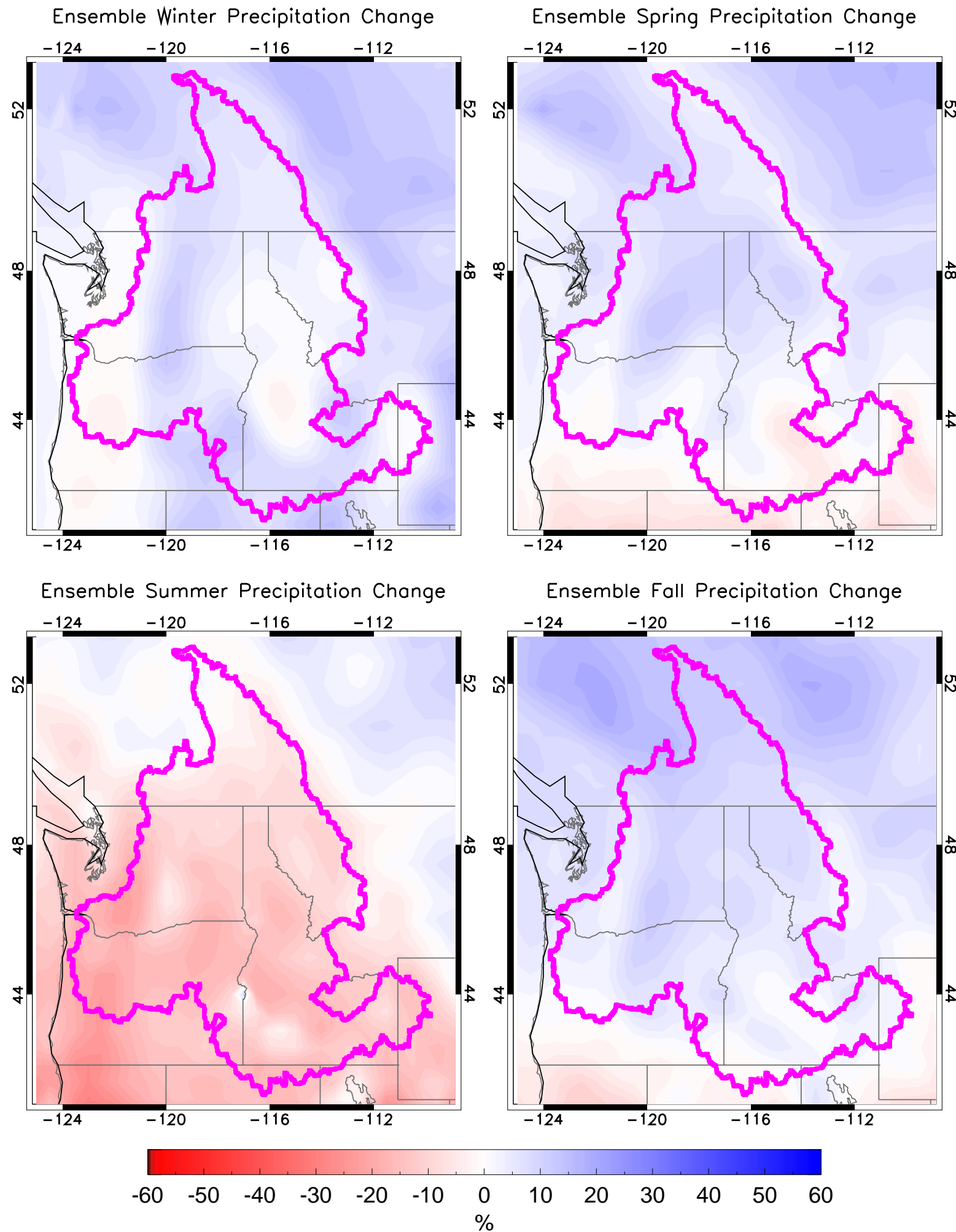
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NARCCAP 2050s* precipitation change

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What next?

Hydrologic simulations of western US

2 hydrologic models (VIC, ULM) driven by MACA-downscaled CMIP5 (UW, UI, OSU). Estimated completion: autumn 2014.

Hydrologic sensitivities

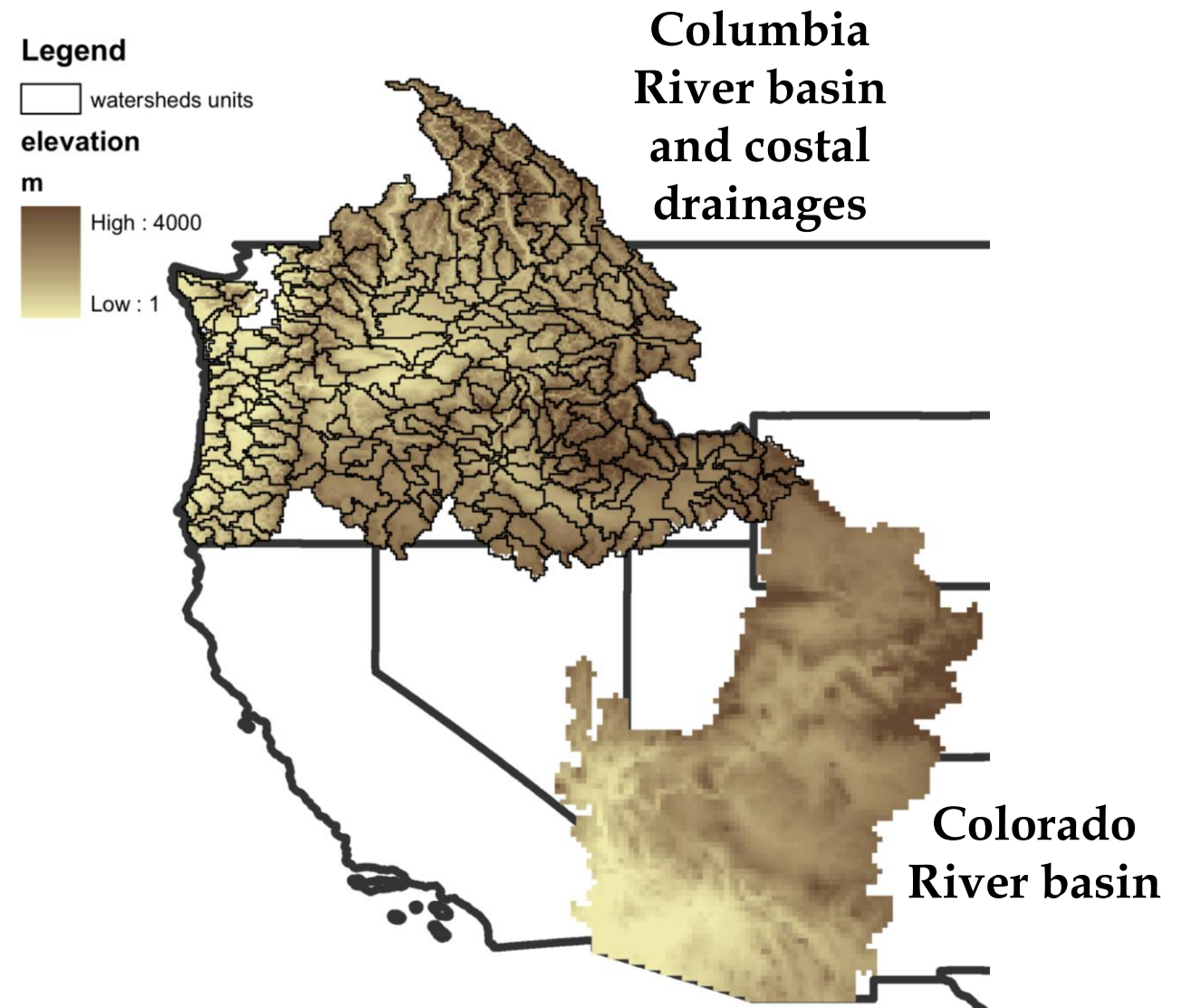
Hydrologic response to step changes in temperature and precipitation. VIC-based (UW, OSU)

Using land surface models to investigate how sensitive runoff is to climate change

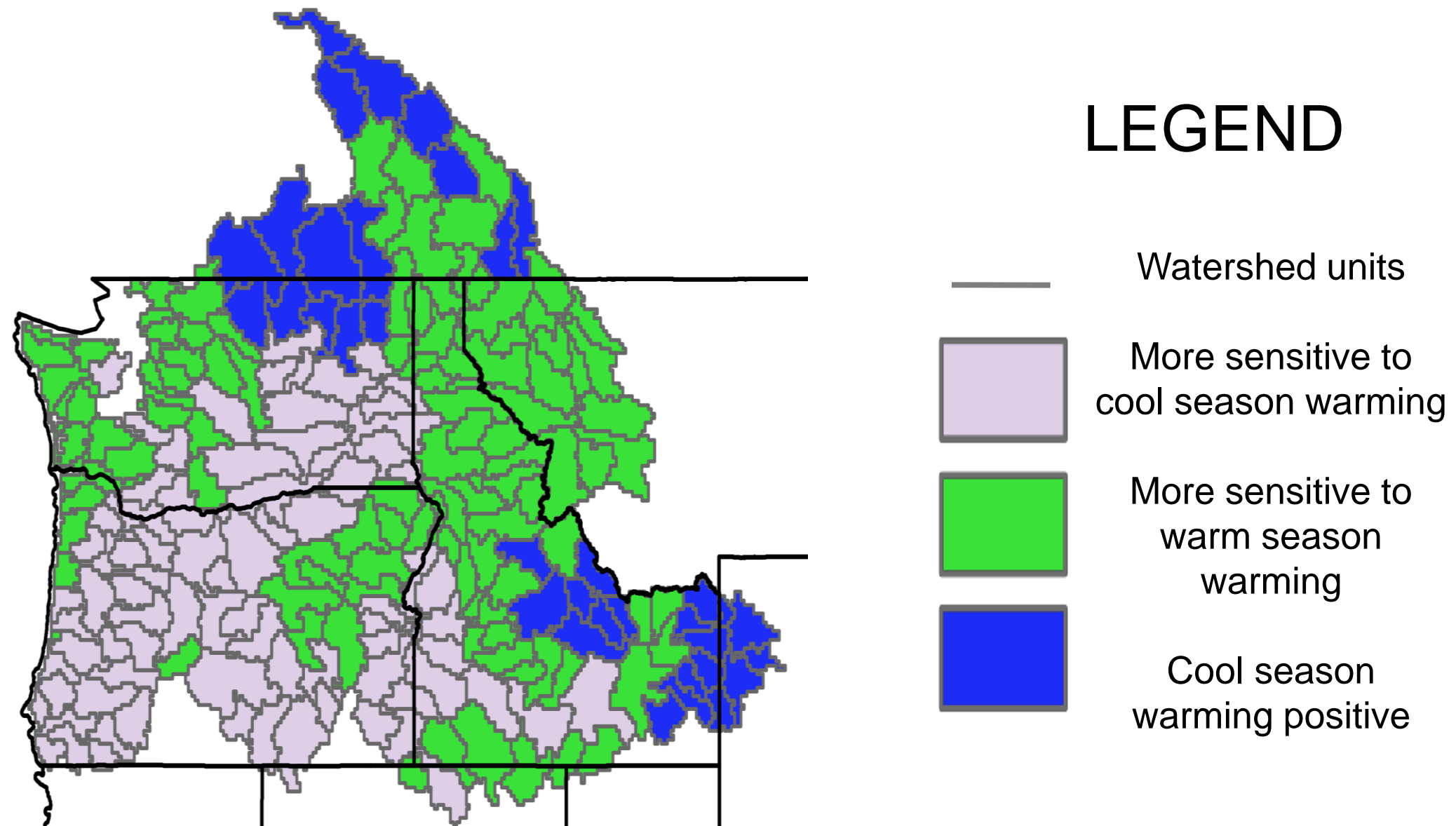
$$\text{Precipitation Elasticity} = \frac{Q_{\text{ref}+1\%} - Q_{\text{ref}}}{Q_{\text{ref}}} \cdot 1\%$$

$$\text{Temperature Sensitivity} = \frac{Q_{\text{ref}+0.1^\circ \text{C}} - Q_{\text{ref}}}{Q_{\text{ref}}} \cdot 0.1^\circ \text{C}$$

Spatial Differences

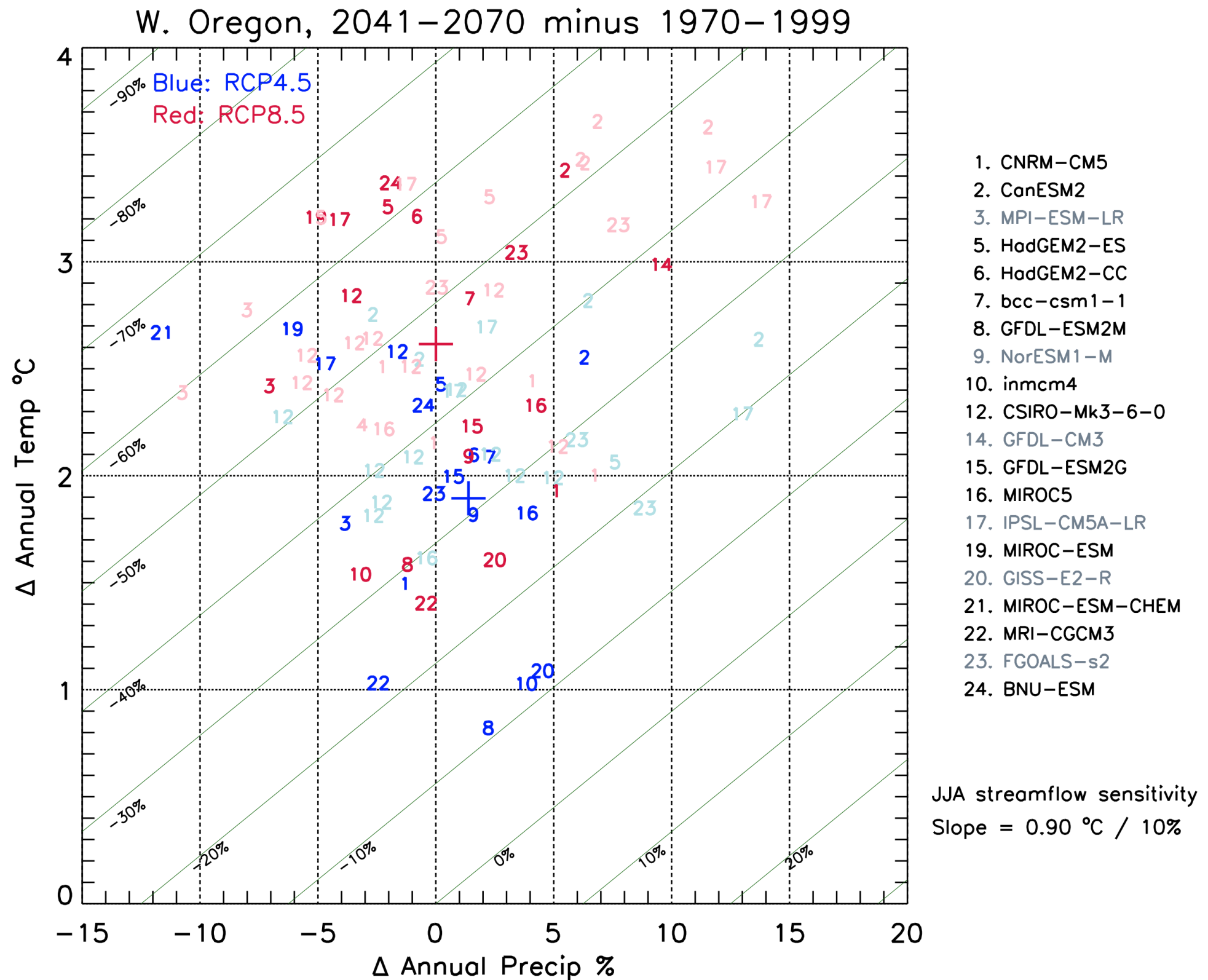


*Categories of Sub-basin Responses to changes in **annual** flow*



Climate change projections and hydrologic sensitivities

Example: Summer, Willamette Basin streams





OCCRI
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